Chapter 10 – Pressure Systems Safety (REDACTED)

10.1 Introduction

Pressure systems are systems in which fluids are contained at pressures other than atmospheric pressure (higher or lower). Numerous containment methods exist, including vessels, piping, tubing, and hoses. Pressure systems are potentially hazardous because when they fail, one or more of the following may occur: the discharge of metal fragments at high velocities; the throwing off of heavy objects such as vessel end plates; the violent whipping action by pipes, tubing, and flexible hoses; the release of high-pressure fluids; and the release of toxic or flammable fluids.

10.1.1 Applicability

This manual is applicable to: (1) all Ames Employees; and (2) all persons and entities who agree in writing to comply with this manual.

10.1.2 Coverage

This chapter sets out standards and procedures for the design, fabrication, testing, inspection (initial and periodic), and certification of pressure systems at Ames Research Center (ARC). It applies to all new and existing, temporary and permanent pressure systems and associated equipment in both aircraft and ground-based systems. Examples of systems covered by this chapter are high-pressure air and water systems, wind tunnel shells, steam lines, cryogenic systems, hydraulic systems, aviation fuel systems, experimental hardware on aircraft, and vacuum systems. This chapter requires that the design, fabrication, testing, inspection, and (re)certification of all such systems (except as noted below) conform to the appropriate Codes and Standards, and any additional requirements stipulated by the Pressure Systems Safety Committee (PSSC).

10.1.3 Exclusions

The following systems are excluded from signature (review) requirements stated in this Chapter, but must meet Cal-OSHA, the American Society of Mechanical Engineers (ASME) Pressure Vessel & Piping Codes, and the California Division of Industrial Safety requirements, and must have normal routine preventive and corrective maintenance. It is the User Facility's responsibility to ensure that these systems meet the proper codes and are serviced:

1. Vacuum vessels of less than 100 cubic feet, if they are not man-rated (for definition of man-rated;
2. Pressurized wind tunnel models if the User Facility follows design and safety requirements and review processes for such models that have been approved by the PSSC;
3. Shop and instrument air systems with pressure equal to or less than 150 psi, if they are not charged from a higher pressure source;
4. Water and other hydraulic fluid systems with pressure equal to or less than 600 psi;
5. Pressurized liquid subsystems that are part of "prepackaged, off-the-shelf" equipment if the pressure is less than 3000 psi and the systems have established and reported safety records.
6. Spaceflight hardware, which has its own special requirements and reviews.

10.2 Definitions

1. **Certified Operating Pressure:** The pressure at which a system is certified to operate. It must not exceed the maximum allowable working pressure (Section 10.2.7) and is usually 10 percent below the relief valve's pressure to avoid frequent openings.
2. **Configuration Management Coordinator:** The individual identified by a project to be responsible for ensuring the adequate and accurate identification and documentation of the functional and physical characteristics of any configuration item within the project. This shall be done through a program of change control, records and reports, and audits to verify conformance to documentation.
3. **Dangerous Fluids:** Any toxic, flammable, or highly corrosive fluid. Air, water, steam, and inert gases are generally not considered to be dangerous fluids.
4. **Design Pressure:** The pressure used in the design of a system for the purpose of determining the minimum required thickness or physical characteristics of the components of the system. When applicable, static head must be added to the design pressure. In most instances, the design pressure is the same as the Maximum Allowable Working Pressure (MAWP) (Section 10.2.7).
5. **Deviation:** Any design, fabrication, inspection, or use of pressure vessels, piping, and associated equipment that is not in compliance with the requirements stated in this chapter.
6. **Inspector:** Anyone employed by or under contract to the Government and authorized by Ames to assure that fabricators and installers follow the scope, requirements, and intent of the design specifications.
7. **Maximum Allowable Working Pressure (MAWP):** The maximum system pressure permissible (i.e., includes code-required safety factor) under normal operating conditions. It is the maximum pressure that can be withstood by the weakest element of the system that satisfies all the requirements of the applicable codes while considering corrosion and various external loads. It is normally the basis for setting the pressure-relieving devices that protect the system and it is the highest allowable setting of the lowest-set relief device. In most cases, the design pressure is the MAWP unless the system has been derated for some reason. In any case, the MAWP must not exceed the design pressure.
8. **Pressure Systems:** Systems in which fluids are contained at pressures other than atmospheric pressure (higher or lower).
9. **Pressure Systems Safety Committee (PSSC):** This committee makes policy and recommends design guidelines concerning pressure systems. It conducts reviews and provides approval for deviation from the requirements stated in this chapter at the request of the Pressure Systems Safety Engineer (PSSE) and/or project engineers, system designers, users, etc. The Committee also considers appeals of waivers rejected by the PSSE. The actions taken by the PSSC are recorded in the meeting minutes. (See Chapter 2 for charter)
10. **Pressure Systems Safety Engineer (PSSE):** The person within the Systems Engineering Division designated to review and approve the safety of all pressure systems except those excluded. The design, specification, and certification of new systems as well as the inspection, modification, repair, and recertification of existing systems must be reviewed and approved. The PSSE also occasionally spot-checks and reviews excluded systems for conformance to the appropriate codes.
11. **Waiver:** Requests and records the action taken for systems deviating from the requirements stated in this chapter. A complete definition of deviations that require waivers is given in section 10.5.

10.3 Standard Codes and Guides

All pressure systems must be designed, fabricated, inspected, and tested in accordance with the following codes. Any deviation from these codes must be approved by the PSSE and/or the PSSC. Other codes and guides permitted by NPD 8710.5, NASA Safety Policy for Pressure Vessels and Pressurized Systems, may be used in specific applications with prior written consent from the PSSE who determines the proper code(s) to use and the order of precedence for their use. The governing editions of the codes are those in force at the time of design.

Required codes and informative guides follow:

10.3.1 Pressure Vessel and Pressure Piping Codes

1. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.
2. ASME B31.3 Code for Pressure Piping
3. ASME B31.1 Code for Boiler External Piping (Chemical)
4. American Petroleum Institute (API).
5. National Board Inspection Code, NB 23, "A Manual for Boiler and Pressure Vessel Inspectors," published by the National Board of Boiler and Pressure Vessel Inspectors.

10.3.2 Flight Systems Requirements

1. AIAA S-081 Space Systems-Metallic Pressure Vessels, Pressurized Structures, and Pressure Components
2. AIAA S-081 Space Systems-Composite Overwrap Pressure Vessels (COPV)

10.3.3 General Requirements: NASA

1. NPD 8710.5, NASA Safety Policy for Pressure Vessels, Pressurized Systems
2. NPG 1700.6, Guide for Inservice Inspection of Ground-Based Pressure Vessels and Systems-with changes dated July 13, 2000.

10.3.4 General Requirements: Federal and State Governments

1. Code of Federal Regulations Title 49, Parts 170 through 189.
2. Occupational Safety and Health Standards, OSHA, Code of Federal Regulations, Title 29, Part 1910, Subpart M.

10.3.5 Specific Requirements: Federal and State Governments

1. Department of Transportation Regulations.
2. Joint Industry Conference Hydraulic Standards.
3. Federal Register, Volume 37, No. 202, Title 29 - Labor - Chapter SVII - OSHA, Part 1910, Subpart G, Section 1910.93 and Subpart M.
4. California Administrative Code, Title 8, Industrial Relations, Chapter 4, Division of Industrial Safety:
   a. Subchapter 1, Unfired Pressure Vessel Safety Orders.
   b. Subchapter 2, Boiler and Fired Pressure Vessel Safety Orders.
   c. Subchapter 7, General Industry Safety Orders.

10.3.6 Informative Guides

1. USAF Technical Manual T.0.00-25-233, "Integrated Pressure Systems and Components (Portable and Installed)."

2. American Society for Testing and Materials (ASTM)
3. NASA SP-8043, Design Development Testing
4. NASA SP-8044, Qualification Testing
5. NASA SP-8045, Acceptance Testing
6. NASA SP-8080, Liquid Rocket, Pressure Regulators, Relief Valves, Check Valves, Burst Disks, and Explosive Valves.
7. NASA SP-8083, Discontinuity Stresses in Metallic Pressure Vessels
8. NASA SP-8088, Liquid Rocket Metal Tanks and Tank Components

10.4 Supplementary Requirements

The matters covered in this paragraph have been determined by the PSSC to be particularly important to the safe operation of pressure systems. They are the result of policy set by the committee and, as such, are mandatory even if they are not in the codes. They are listed by subject (i.e., bolting, welding, etc.), in alphabetical order.

10.4.1 Accumulators

Accumulators with diaphragms should be charged with an inert gas rather than air or gases that support combustion.

10.4.2 Cadmium Plating

Cadmium (electrodeposited) plating shall not be used on steel components including fasteners that have an ultimate tensile strength greater than 200 ksi. If cadmium plating of components with strength levels less than 200 ksi is required, it shall be performed per Federal Specification QQ-P-416F. Because of the inherent hazards involved with electrodeposited cadmium, alternate coatings should be considered when possible.

10.4.3 Color Coding

Color coding and marking of pressure vessels and piping shall be performed as required by the PSSE.

10.4.4 Compatibility of Fluids

The compatibility of all fluids with vessel structural materials and contained fluids shall be considered.

10.4.5 Fasteners

Bolts, studs, and nuts used in flanges must conform to the proper code listed in section 10.3.1:

1. Bolts, studs, and nuts must be marked to indicate the material and grade and must be accompanied by certifications of conformance from the manufacturer in compliance with AHB 1200-1.
2. New bolts and studs are recommended; however, if the old fasteners are reused, they must be inspected for signs of cracking and deformation as specified by the PSSE.
3. Bolt elongation dimensions or torque values must be shown on the drawings.

10.4.6 Flexible Hoses

Hoses are not considered permanent substitutes for tubing or piping. If they are used, they must be labeled for operating pressure at installation and periodically inspected as stated in section 10.9 of this chapter. Further, hoses must be tied down at end connections.

10.4.7 Gages

Gages must meet the following requirements:

1. Any gage used in a pressure system must be of a safe type that features a full blowout back, an internal flow restrictor, and an armored plate behind the dial. Gages less than two-inch scale diameter with internal flow restrictors are exempted.
2. Safe practice indicates that all gages be inspected periodically.
3. If a gage is damaged by overstressing, it must be replaced.
4. Gages that have been identified as critical safety items must be inspected and calibrated periodically to ensure accurate measurement. Recalibration periods are listed in section 10.9 in this chapter.
5. Gages whose accuracy is not considered critical to the safe operation of a system shall be clearly marked "INDICATION ONLY."
6. The operating pressure should fall in the middle half of the gage scale. All gages must be mounted so that safety features will function. (Gages with blowout backs, for instance, must not be mounted so as to prevent blowout of back in case of malfunction.)

10.4.8 Gaseous Hydrogen Pressures Systems

The potential for hydrogen embrittlement must be addressed through proper selection of materials and operating conditions. In general, the following materials should not be used in hydrogen containing systems: titanium, maraging steels, 400-series stainless steels, steel per MIL-S-16216 or ASTM 514 and ASTM 517, steels listed in section 2.3 of MIL-HDBK-5, and precipitation-hardening stainless steels. Preferred construction materials include low strength carbon steels, such as ASTM A-36, and austenitic stainless steels, such as AISI 304, AISI 304L, AISI 316, and AISI 347. For materials not addressed above, assistance should be sought from the PSSE and/or the PSSC.

10.4.9 Manufacturers' Ratings

Manufacturers' ratings must be approved by the PSSE if components are not specified in the required codes.

10.4.10 New Pressure Vessels

All new pressure vessels purchased are to be code stamped and registered with the National Board.

10.4.11 Pressure Testing

Pressure testing establishes the ability of pressure vessels, piping, and fittings to withstand the maximum pressures anticipated for the equipment. The test pressure is set by the code to which the pressure system is built. If the applicable code is unknown or cannot be determined, a hydrostatic test pressure of 150 percent of MAWP is recommended and analyses must be conducted to verify that the system can safely withstand the test pressure.

Inert liquids must be used for pressure testing whenever possible. Incompressible fillers may be used if practical. Liquids, being less compressible, are safer than gasses in pressure systems. However, liquid pressure systems do store energy and must also be considered hazardous to some degree. If a hydrostatic test or other inert liquid pressure test cannot be conducted, a pneumatic test may be conducted if allowed by the applicable code. A pneumatic test must be requested by a written waiver and approved by the PSSE, with the concurrence of the Chairman, Pressure Systems Safety Committee. High-risk tests also require review by the PSSC. Special precautions, beyond those mandated by codes, may be required to ensure safe conductance of a pneumatic test.

All pressure tests must be conducted in accordance with the applicable code; require prior review and approval; and must be witnessed by the PSSE or his/her representative. Appendix 10-A describes a pressure test procedure and illustrates an approval sheet to be used in all tests.

10.4.12 Pressure Regulators

Pressure regulators and/or automatic control systems must be used on a pressure source to protect the downstream items from overpressure.

10.4.13 Radiographic Inspection

Radiographic inspection of "last welds," with magnetic particle or penetrant inspection of the first and last pass of the last weld, rather than pressure testing, may be permitted in cases where modifications to existing systems result in one or more welds that cannot readily be pressure tested. However, this is considered a deviation and a waiver is required. Further, these welds must be tested during the periodic system recertification. (See Section 10.7)

10.4.14 Relief Devices

Relief devices must be located in all stages of the pressure system. Piping sections isolated by isolation valves must be protected against accidental overpressurization. Vessels filled with liquid must be equipped with liquid relief valves.

10.4.15 System Integrity

The integrity of all new pressure systems or those that have had repairs and/or modifications made to the pressure envelope shall be verified by an appropriate pressure test that follows the procedures in section 10.11.1. However, if a pressure test is believed to be unnecessary or detrimental to overall system performance and safety, a waiver may be requested as described in section 10.5. The waiver should cite a substitute or alternative procedure that will provide assurance of integrity of the pressure system.

10.4.16 System Maintenance

No system shall be pressurized during maintenance (including tightening of bolts), repair, or modification of that system. Sections subject to these operations shall be, as a minimum, isolated by a valve physically locked to prevent operation, or if failed closed, with the actuating system physically disabled.

10.4.17 Tubing

All tubing must be seamless. All fittings must be installed in strict accordance with manufacturer's recommendations, particularly when selecting thickness and strengths. Of compression fittings, only SWAGELOK fittings are permitted.

10.4.18 Unstamped Pressure Vessels and Systems

Unstamped Pressure Vessels will not normally be accepted except for unique requirements and configurations that do not lend themselves to code designs. If accepted, however, they must be made from code-approved materials and, as much as possible, must be designed, fabricated, and tested according to the proper code. The lack of a stamp on a pressure vessel must be treated as a deviation for approval purposes.

10.4.19 Welding

1. Welding operations on pressure systems must be done only by welders who are currently certified for the type of welding to be performed in accordance with the ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
2. Each Contractor must submit to the Contracting Officer proof of the certification of each welder before the start of work.

3. All welds on pressure vessels other than those for attaching lugs, supports, etc. must be, as a minimum, spot radiographed according to the ASME Boiler and Pressure Vessel Code. In addition to the requirements of the applicable code, for each welded pressure system involving operating pressures between 140 and 300 psig (inclusive) sample welds totaling 5 percent of the total weld footage as selected by the PSSE must be radiographed. For each system operating at a pressure in excess of 300 psig, 100 percent is required. If joint geometries preclude the use of radiography, then some other inspection techniques must be used as approved by the PSSE.
4. Defective Welds - All faulty welds must be repaired and reinspected. The requirements of the applicable code for repair, retest, and further inspection shall be met. Where the applicable code does not specify a requirement for additional inspection for those cases where a rejectable weld is found, the requirements of ASME Code Section VIII, Div. 1, shall be followed.

10.4.20 Windows

Windows that are part of the pressure boundary should be avoided as much as possible. Indirect viewing rather than direct viewing should be employed wherever possible. Special caution should be observed to avoid mechanical damage to windows.

1. Supports/Mounts are critical in maintaining low, uniform stresses in windows. Edge boundary conditions should approach pinned rather than fixed conditions.
2. Stress levels in windows should be less than 300 psi to avoid structural degradation due to static fatigue (i.e., crack growth under sustained stress). Higher stress levels necessitate frequent, rigorous inspections for cracks and defects.
3. Proof testing should be performed after initial installation to verify window fabrication and mounting adequacy. Proof-level pressure should not be held for extended periods, but relieved as soon as possible following verification of the integrity of the window and frame. Additional proof testing for recertification purposes is not recommended.

10.5 Deviations from Standards

All deviations from the requirements stated in this Chapter in effect at the time of design must be presented in writing by the Designer for approval by PSSE and at his discretion, with the concurrence of the Chairman, PSSC. If the deviation approval is controversial or has the effect of making new Center-wide policy, the Pressure System Safety Committee must also concur. At least 48 hours must be allowed for the approval process. The Quality System Request for Deviation/Waiver Form (ARC 762) is used to document the justification and approvals when the requirements of this manual cannot be met. Deviations requiring approval include pneumatic pressure test instead of hydrostatic pressure test and/or elimination of pressure test for "last" welds. If the deviation is not approved by the PSSE, the ruling can be appealed directly to the PSSC.

10.6 Design and Approval

All pressure system designs, pressure system modifications, and pressure testing require prior review and approval of, and will be performed under the direction of, the Pressure Systems Safety Engineer.

10.6.1 *The Designer*

The Designer must submit the following items to the PSSE for approval prior to the final design review:

1. **System Description -** in narrative format, to include such information as: the system's history (including prior system fluids, cycling, etc.); a brief description of the hardware; the

function of the system (brief technical review); a description of the system's contents, including the normal operating pressures and temperatures; and full information as to the hazards of the fluid(s) to be contained, especially if lethal fluids or those causing embrittlement (such as hydrogen, some acids, or corrosives) are to be used.

2. **Systems Schematic Diagram -** to identify functional system components that will require recertification. The approximate physical location of each component is indicated and assigned an identification number.
3. **Component Inventory Sheets -** to indicate data required for the determination of recertification requirements. Because this data varies for different classes of components, several different types of component inventory sheets are used for each system.
   a. For Component Inventory for Piping and Piping Components, consult section 10.11.3 which sets out the format and instructions used for preparing this sheet.
   b. For Component Inventory for Relief Valves and Rupture Discs, section 10.11.3.
   c. For Component Inventory for Pressure Vessels, Tanks and Vacuum Vessels, consult section 10.11.3.
4. **Pressure Vessel Record Sheets -** must be prepared when original Manufacturer's Data Sheets are not available for pressure vessels, tanks, or vacuum vessels. The purpose of these sheets is to provide a permanent record of the summary information normally included on a Manufacturer's Data Sheet and to determine the general suitability of the intended application. These sheets are prepared in accordance with the instructions in section 10.11.3.
5. **Design Calculations -** must include the codes to be used, material selection criteria, the pressure calculations, corrosion allowances, flexibility calculations, component strength calculations, support calculations, fatigue life calculations, and relief device capacity calculations.
6. **Drawings and Specifications (Bid Package) -** drawings must be entered in the Ames Engineering Documentation Center (EDC) records in Bldg. 213, to be replaced by "as built" drawings when construction is completed.
7. **Pressure test, periodic inspection and recertification plans, and schedules.**

10.6.2 *The Project*

1. Design the system to permit tests, installation, checkout, and maintenance (e.g., flanges for isolating sections of the system, vents, drains, adequate foundations to support hydrostatic weight, special tools, etc.).
2. Prepare specifications, purchase requests, and other instructions in sufficient detail to ensure that the contractor, fabricator, or installer understands the requirements of the standard codes and any additional requirements that must be met.
3. Provide for meeting the basic pressure system requirements specified by the facility operations manager and retain the responsibility for such pressure systems up to and including the final systems acceptance testing. This includes the responsibility for all coordination necessary to obtain compliance with these regulations by the Facility Coordinator, Facility Supervisor, Designer, PSSE, Inspector, Fabricator, and Installer; and the responsibility for all design and operational reviews.
4. Obtain permits and prepare environmental impact studies.
5. Ensure that an Inspector is assigned to inspect all new pressure vessels, piping and associated equipment, and all alterations, repairs, and additions thereto.

10.6.3 *The Pressure Systems Safety Engineer*

1. Examine drawings, calculations, test and recertification plans, parameters, checkout procedures, specifications, and statements of work. Either approve them as conforming to these regulations and the applicable codes, require that additional work be accomplished to bring the non-conforming item(s) into compliance with the applicable code, or direct that waivers be prepared to cover the deviations (see section 10.11.2).
2. Evaluate the overall safety of the system, in its entirety, and be completely satisfied before approving the design as noted in (1) above.
3. Retain a copy of all system specifications and supplemental documents.

10.6.4 *The Inspector*

1. Ensure that the fabricator and the installer follow the drawings and the specifications generated by the Designer and/or the Project Engineer and ensure that they conform to the codes specified by the Designer.
2. Witness all tests specified by the Designer.
3. Verify that test apparatus is calibrated properly before use.
4. Interpret X-ray film and ensure that the quality of the process and its results are of the level required by the applicable code(s) and that the acceptance 5. Coordinate with the PSSE in resolving any problems in the interpretation of specifications that involve these regulations.
5. Ensure that the Contractor meets the normal construction codes.

10.7 Final Operating Approval, Certification, and Recertification

Review and recommendation for final operating approval is made by the Operational Readiness Review Committee designated for the system or facility.

Certification is the documentation attesting that a pressure system is designed and fabricated in accordance with the requirements of the approved codes, standards, or guides listed herein, and is safe to operate at a specified pressure under specified environmental and other operating conditions. After the pressure system has been fabricated and installed, the Project Engineer must assemble all the documentation developed by the Designer (as discussed in section 10.6), "as-built" drawings, Inspector's reports, proposed inspection and recertification schedules, and submit them to the Facility Operations Manager for inclusion in the Administrative Operations Manual for the facility. The "as-built" drawing, etc., should replace the bid package in the Engineering Document Control (EDC). System certification must also include a recertification plan for the recertification file maintained by PSSE.

Recertification is the performance of periodic acts (documented in writing) to show that a previously certified pressure system continues to be safe to operate. Such acts, which may include periodic inspections or tests, are defined in a recertification plan in accordance with NPG 1700.6A Guide for Inservice of Ground-Based Pressure Vessels and Systems - with changes 1-8, dated July 13, 2000.

10.8 Configuration Management

The Project Engineer must submit a copy of all items listed in Section 10.7 to the Configuration Manager for the pressure system.

10.9 Periodic Inspection and Maintenance

Relief valves and gages must be recalibrated and flexible hoses retested periodically. The Facilities Operations Manger must prepare a maintenance and inspection schedule for the pressure system, including the proposed inspection and recertification schedule that was prepared

by the Project Engineer and approved by the PSSE. This schedule will be given to the PSSE for incorporation into the Center's computerized Recertification/Maintenance plan.

10.9.1 Inspection Intervals for Relief Valves and Pressure Gages

1. Retesting periods for relief valves and pressure gages must not exceed two years for valves and gages in the following services:
   a. Gaseous: Argon, Helium, Nitrogen, Dry Air, Oxygen, Hydrogen, Natural Gas, and Fluorine
   b. Liquids of: Argon, Helium, Nitrogen, Oxygen, and Fluorine
   c. Others: Hydrogen Peroxide (90 percent), Nitrogen Tetroxide, Inhibited Red Fuming, Nitric Acid, and Vacuum
2. A one-year inspection period must be maintained for the following:
   a. Water or Nonflammable Hydraulic Fluids
   b. Liquids of Hydrogen, Natural Gas, Monomethyl Hydrazine, Hydrazine, UDMH, UDMH/ Hydrazine Aniline, Furfuryl Alcohol, Kerosene (RF-1)
   c. All unlisted gases and/or liquids unless otherwise determined by the PSSE.

10.9.2 Inspection Intervals for Hoses

1. All flexible hoses, their connections, and tie-downs must be visually inspected annually.
2. All flexible hoses, except vacuum hoses, must be tested periodically as specified in number 3 to 1.5 times the design pressure.
3. Retesting periods must not exceed the following:
   a. Five years for hoses in the following services: Gaseous: Argon, Helium, Nitrogen, Oxygen, Hydrogen, Air, and Natural Gas (all under 200 psig), Liquids (of): Argon, Helium, Hydraulic Fluid, Nitrogen, Aniline, Furfuryl Alcohol, Kerosene, Hydrogen Peroxide (90 percent), Nitrogen Tetroxide, and Inhibited RFNA
   b. Three years for Gaseous Oxygen, 200 psig or higher.
   c. A two-year period must be maintained for service hoses carrying all other gases and/or liquids. Systems with difficult access may lengthen the inspection interval with approval of the PSSE.

10.10 Protective Lockout and Tagging of Equipment

HOLD-OFF and SPECIAL CONDITIONS tags are used to call attention to situations where maintenance work that requires equipment lockout is being performed and/or where such equipment may be operated only under certain specific, limited conditions. The Hold-Off tags are also used to remove uncertified systems or components from operation. These tags must be honored because the lives of personnel depend on it. Specific criteria for applying and removing these tags to ensure safe conditions are presented in section 11.3.

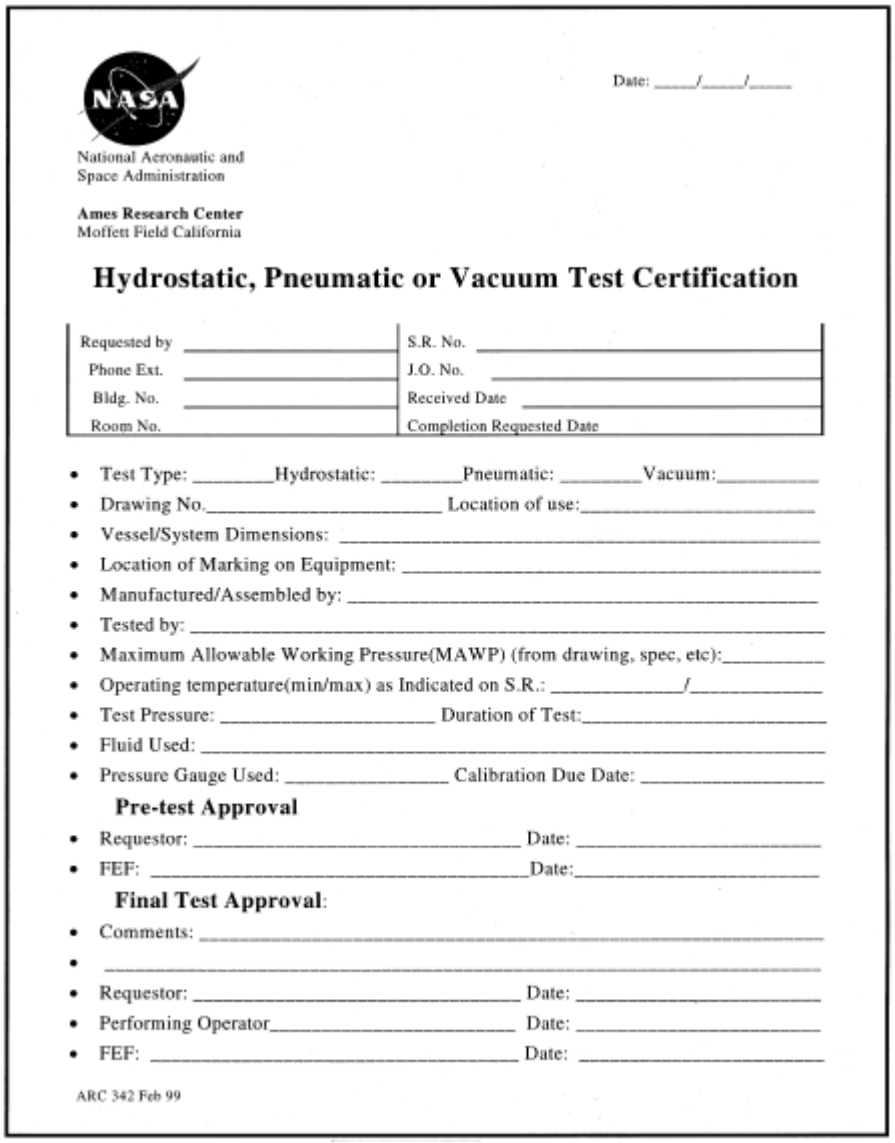
10.11 Appendices

10.11.1 Appendix A: Hydrostatic Test Guidance and Information

See Hydrostatic, Pneumatic, or Vacuum Test Certification Form (ARC 342), section 10.11.2

1. Use only safety gages. All gages must be recorded, numbered, calibrated within the past year, and kept in good working condition.
2. All gages must be calibrated according to Reliability and Quality Assurance (R&QA) standards.
3. Do not exceed 75 percent of rated gage pressure.
4. Gage selection must be according to test pressure required, which should fall in the middle third of the dial. Note that the hydrostatic test pressure is generally 150 percent of the maximum allowable working pressure.
5. Maximum allowable working pressure or desired operating pressure, the location when in use, and the liquid to be used must be written on the ARC 73, Service Request, by the requester. It is also the requester's responsibility to contact the Pressure Systems Safety Engineer prior to the test to familiarize him/her with the specific application.
6. All hydrostatic tests must be logged on the Hydrostatic, Pneumatic or Vacuum Test Certification Form (ARC 342) illustrated in section 10.11.20.
7. All items tested must be marked by date and pressure.
8. Inspect all materials involved in the test prior to assembly to ascertain that they are satisfactory.
9. Fasteners must be of proper size and grade.
10. All valves, fittings, components, etc., even if only temporary for the duration of the hydrotest, must have a pressure rating consistent with the maximum test pressure to be encountered.
11. Pressure gages must be located on the vessel being tested so as to be easily read by the person conducting the test, and must be protected against pulsation.
12. The test article should be at least 60°F for the test
13. Erect barricade, post signs, and isolate the test area. Shroud the test vessel where possible. All testing must be from a remote test station, when possible.
14. Remove all nonessential personnel from the area.
15. Check pipe or vessel supports.
16. Tie down all hoses.
17. Vessels, piping, flanges, etc., require vents located at high points, as necessary, to vent the air.
18. Drains should be provided at low points, as necessary, to completely empty the vessels and components following the hydrotest.
19. In large, fixed systems provisions for a dry air (or nitrogen) purge following the hydrotest should be considered.
20. Remove all possible air by running liquid until all bubbles are removed, including pump and piping.
21. Pressure must be applied slowly and then held at maximum test pressure for ten minutes.
22. Prior to close visual inspection, the pressure must be lowered 20% of existing pressure. Example: 5000 psi must be lowered to 4000 psi before inspection.

10.11.2 Appendix B: Hydrostatic, Pneumatic, or Vacuum Test Certification (ARC 342)



National Aeronautic and
Space Administration

Ames Research Center
Moffett Field California

Date: ____/____/____

Hydrostatic, Pneumatic or Vacuum Test Certification

Requested by _____	S.R. No. _____
Phone Ext. _____	J.O. No. _____
Bldg. No. _____	Received Date _____
Room No.	Completion Requested Date

- Test Type: _____Hydrostatic: _____Pneumatic: _____Vacuum:_____
- Drawing No._____ Location of use:_____
- Vessel/System Dimensions: _____
- Location of Marking on Equipment: _____
- Manufactured/Assembled by: _____
- Tested by: _____
- Maximum Allowable Working Pressure(MAWP) (from drawing, spec, etc):_____
- Operating temperature(min/max) as Indicated on S.R.: _____/_____
- Test Pressure: _____ Duration of Test:_____
- Fluid Used: _____
- Pressure Gauge Used: _____ Calibration Due Date: _____

Pre-test Approval

- Requestor: _____ Date: _____
- FEF: _____Date:_____

Final Test Approval:

- Comments: _____
- _____
- Requestor: _____ Date: _____
- Performing Operator_____ Date: _____
- FEF: _____ Date: _____

ARC 342 Feb 99

10.11.3 Appendix C: General Hydrostatic Test Checklist

The hydrostatic test of all vessels is to be conducted in accordance with all applicable requirements of the ASME Code, Section VIII, Division I or II, the National Board Inspection Code NB-23, and the Ames Research Center Health and Safety Manual APG 1700.1. The following checklist summarizes the major requirements of these codes. A copy of this checklist (or one similar) should be filled out at the time of each hydrotest and filed with the vessel's documentation package.

Performing Test Pressure	
Organization	
Sign-Off	
A normal hydrostatic test is conducted at 1.5 times the Maximum Allowable Working Pressure (MAWP) for the vessel or system. (At Ames Research Center, the MAWP is considered to be the maximum relief valve or burst disk pressure and should not exceed the design pressure.) The system must remain at this pressure for a minimum of ten minutes.	

Maximum Relief Valve psi X 1.5 = psi Setting

1. Documentation	**Check**
a. Fill out form ARC 342, "Hydrostatic, Pneumatic, or Vacuum Test Certification"	
b. If applicable, have contractor fill out a National Board Form R-1 for repairs or modifications.	
2. Equipment, Gauges	**Check**
a. Gauges are solid front, safety type, with blowout backs.	
b. Gauges to be used will have the hydro pressure reading in the middle third of the gauge.	
c. Gauges have been calibrated within six months of the date of the hydrotest.	
d. Gauges are located to permit monitoring of the pressure without exposing personnel to the vessel(s) being tested.	

Some common gauges and their hydro ranges	
Gauge Rating (psi)	Acceptable Hydrotest Range
10,000	3300-6700
5000	1650-3350
2500	800-1600
1500	500-1000
1000	330-670
750	250-500
500	165-335
150	50-100

3. Equipment, Safety Relief Valve	**Check**
a. The hydrotest-pressurizing pump is equipped with a safety relief valve capable of passing the full volumetric capacity of the pump at the test pressure.	
4. Equipment, Hoses	**Check**
a. All hoses used in the hydrotest have a rating equal to or greater than the hydrotest pressure, have been tested within one year to 1.5 times the hose pressure rating, and have an attached tag indicating the most recent test date and test pressure.	
5. Safety	**Check**
a. All air has been vented from the vessels (vessel high spots bled) prior to application of pressure.	
b. All non-essential personnel escorted from area prior to application of pressure. Only those people necessary to conduct or witness the test are to be in the area after pressurization has begun.	
c. All personnel involved with the test are protected by a suitable barrier from the time pressure is applied to the time that pressure has been reduced to 80 percent or less of the test pressure. Visual inspection after a successful test is not to be attempted until pressure is reduced to 80 percent or lower of the test pressure. Test Pressure _____ x 0.80 = _____	
d. If for any reason the test does not proceed to the full test pressure and remain at that pressure for a full ten minutes, then all personnel are to remain protected until the applied pressure has dropped to 50 percent, or less, of the maximum pressure reached.	
6. The area is to remain secured until either:	**Check**
a. In the case of a successful test the pressure has dropped below the Maximum Allowable Working Pressure or,	
b. In the event of an unsuccessful test all pressure is removed from the vessels.	
7. General	**Check**
a. Vessel temperature is at least 60°F at the time of the test.	
b. The pressure was applied slowly and then held at the maximum test pressure for at least ten minutes.	
c. All leaks or permanent distortion have been recorded. Any leaks (other than seal leaks) or permanent distortion will be cause for rejection of the vessel/piping system.	
d. After completion of the test the pressure was reduced to ambient, all water drained from the system, and the interior surfaces dried by appropriate means.	

10.11.4 Appendix D: Procedure for Documentation & Approval Of Pressure Deviation/Waivers

See Pressure Deviation/Waiver Request Form, section 10.11.5 1.

1. PURPOSE: This procedure sets out instructions for preparing and processing a Quality System Request for Deviation/Waiver (ARC 762) http://server-mpo.arc.nasa.gov/Services/AEFS/AEFSHome.html. A waiver may be granted when the standards of this chapter or the requirements of the appropriate code listed in section 3 cannot be met; however, the approval of any deviations from the standards is required before the system can be pressurized - even for test purposes.

2. REQUIREMENTS: The request for a Pressure Deviation/Waiver must be submitted to the PSSE who tracks the processing of the request. The PSSE coordinates with the System Safety and Mission Assurance Division (Code QS) in their efforts to centralize the processing of Deviation/Waiver requests.

   When the standards of this chapter or the applicable codes cannot be met, a request for deviation/waiver with adequate justification must be submitted to PSSE. The PSSE coordinates the request with the PSSC, Code QS, and with technical support elements as appropriate for technical and safety evaluations of the system as well as evaluation of the testing and operational requirements. The requesting organization must prepare the deviation/waiver request in accordance with instructions and format shown on the following two pages. If the Deviation/Waiver is approved, any required corrective such as repair, inspection, or test must be accomplished prior to pressurization of the system. Inspection or test activity must be coordinated with a qualified Inspector. The requesting organization must ensure that a copy of the Deviation/Waiver Request is filed in the vessel/system data package.

3. Preparation and Processing Instructions for Quality System Request for Deviation/Waiver Form (ARC 762) are found in Work Instruction for Deviation/Waiver (53.ARC.0013.1) http://server-mpo.arc.nasa.gov/Services/AEFS/AEFSHome.html except that the following criteria are unique to Pressure Systems and shall be followed in lieu of sections 6.3 through 6.6.5.1 of the Work Instruction.

   - In section 4, describe the subject of the waiver, i.e., What requirement is to be waived? Example: Request that the requirement for hydrostatic proof test on Pressure System UVXYZ be waived and an equivalent pneumatic test be substituted.

   - Explain in detail the justification for the waiver request. Why must there be a deviation from standard practice or stipulated code requirement? Why is it safe to do it? Also include other pertinent information, such as nomenclature, identification numbers, system designation, location, fluid used, normal operating pressure, Maximum Allowable Working Pressure, Design Pressure (if different), etc. A proposed schedule of performance for any necessary fabrication or testing must also be included. Identify residual risks after mitigation and RAC Code of residual risk (see NPG 8715.3). State that the Owner's organization accepts the risks of operating in the waived condition. Attach additional pages as necessary.

   - Obtain signature approval for the waiver from the cognizant Division Chief for all waivers. Obtain Code Directorate approval for RAC codes 3 and lower, and Center Director approval for RAC codes 1 and 2. Center Director and/or Enterprise approvals may be required for policy waivers consistent with the requirements of NPG 8715.3 for waivers from Pressure Safety Policy as delineated in NPD 8710.5 (current revision). The requisite Owner and Director (if required) approvals must be obtained before the PSSE will consider the Waiver request.

- Obtain signature approval from the PSSE on the ARC Form 762.
- Obtain signature approval from the Chairman PSSC on the ARC 762.
- Obtain signature approval from the Chief, Code Q, only on the ARC 762. Code Q will enter the deviation/waiver into the Q database and file the original ARC 762.
- Return a copy of the Pressure Deviation/Waiver Request to PSSE at mail stop 213-8.
- The PSSE informs the requestor of the results of the Deviation/Waiver Request.

10.11.5 Appendix E: Pressure Deviation/Waiver Request Form (ARC 547)

Request for Deviation/Waiver
NASA Ames Research Center

S/N: (assigned by DQ)

(1) Organization:
Facility or Project:
Subsystem or Work Package:

(2) Request for: ☐ Deviation ☐ Waiver

(3) Documents Affected

Number	Rev.	Title

(4) Describe Deviation/Waiver Requested: (Provide a brief description, identify specific requirements or codes affected, and attach any drawings/sketches.)

(5) Deviation/Waiver Justification: (Include effect on cost, schedule, performance, etc.)

(6) Requestor: Org: M/S:

Signature: Phone: Date:

(7) Approval Required	Comment (See Reverse)	Activity	Approval Signature	Date
Yes	☐ Yes ☐ No	Division Chief:		
Yes	☐ Yes ☐ No	Code Q:		
☐ Yes ☐ No	☐ Yes ☐ No	Organizational Director:		
☐ Yes ☐ No	☐ Yes ☐ No	Deputy Director:		

Request for Deviation/Waiver (ARC 547) Instructions
NASA Ames Research Center

Purpose: A Non-Contractual Deviation/Waiver request is submitted to accept a hardware part or facility construction that does not conform to the applicable codes, requirements, or specifications.

Instructions for Preparation:

A. Originator completes blocks (1) through (5):

1. Provide the information requested to identify the facility/project, the requesting organization, and the subsystem/work package. Obtain the cognizant Division Chief's approval after completing blocks (1) through (5).
2. Identify whether the request is for a Deviation or Waiver:

   Deviation: A request, made during Planning or design of an item, to depart from a particular performance or design requirement of a specification, drawing, or other document for a specific number of units or for a specific period of time.

   Waiver: A request to accept an item which, during manufacture or after having been submitted for I is found to depart from specified requirements, but nevertheless is considered for use "as is" or after repair by an approved method.
3. Identify the document(s) that specify the requirement(s) that the Deviation/Waiver is written against. List document identifying number, revision status, and title.
4. Provide a brief description of the Deviation/Waiver. Identify the specific requirement for which the Deviation/Waiver is requested. Include document paragraph number or references, and attach drawings or sketches, as applicable.
5. Identify the reason that a Deviation is required in lieu of complying with the specified requirements. Identify the reason the Waiver is requested to accept *as is* or repair a hardware defect or discrepancy in lieu of complying with the requirements. Identify any effect that approval/disapproval will have on cost, schedule, performance, etc.
6. Provide requested information and signature.

B. Send completed request to Code Q for proper routing and approval:

7. Code Q: (a) reviews the Deviation/Waiver request for completeness, (b) dates the request, (c) assigns a Serial Number, (d) indicates approval or disapproval of the request and signs the request in the space provided. If the request is disapproved, Code Q will return the request to the originator.

   - Approval Routing: The cognizant Division on Chief and Code Q will review all requests for approval. Code Q will determine what additional approval signatures, if any, are required.
   - Approval of the Request: Signifies acceptance of the requested change. Any exceptions or conditions to the request should be noted in the Comment space provided below. Sign and date any comments.
   - Request Distribution: Upon completion of all required approval signatures, the final form will be returned to Code Q for distribution and record keeping. Copied to originator.

Comments (including conditions of approval or reasons for denial):

_____

_____

_____

END OF DOCUMENT